is not entirely satisfactory. . . . The modern affinities of the numerous leaves of the higher types of dicotyledonous trees found in it, present a strong objection to the adoption of the conclusion that it may belong to a lower horizon than the Upper Greensand of British geologists; while its position directly below beds almost beyond doubt representing the Lower or Gray Chalk, precludes its reference to any higher stratigraphical position. Consequently, we have long regarded it as most probably representing in part, if not the whole, the Upper Greensand. . . ." As the fossils above mentioned belong to the Museum of Comparative Zoology, I hope to be able to give more detailed information upon these galls and mines.

Cambridge, Mass., January 3 H. A. HAGEN

On Combining Colour-Disks

THE paper of Lord Rayleigh in NATURE (vol. xxv. p. 64) describing experiments on colour, gives near the close a method of observing the image of colour-disks seen through an inverting prism in rapid rotation, while the disks were at rest. This recalls to mind a method somewhat similar that I have tried, that will sometimes be found convenient as well as simple: Here the image of the stationary disks is formed in a plane mirror slightly inclined to the axis around which it rotates; by properly proportioning the angle of inclination, the distances from the mirror to the eye and disks, and the sizes of the mirror and disk, it is obvious that a good combination of the colours may be effected, while the adjustment of colours is easily effected without stopping the rotation. If, as with my instrument, the clockwork is not heavy enough to give easily the desired speed when the disks are mounted on it, a much higher speed can be obtained with the light mirror: indeed, the mirror might be attached to the end of a wire resting on two supports, and rotated by unwinding a string, and thus colour combinations could be simply effected, and with cheap apparatus. Of course here, as with the inverting prism, the line of vision is inconveniently limited; but with both methods the uncertainty arising from unequal illumination of different parts of the disk may be detected by giving to the disk a slow rotation on its own plane.

CHARLES K. WEAD

University of Michigan, Ann Arbor, U.S.A., December 31, 1881

Sound-Producing Ants

WITH reference to the question whether ants produce sounds which are of such a pitch as to be inaudible to the human ear, I should like to make a suggestion which occurs to me, but which I have no means of carrying out practically. It is a well-known acoustical fact that two notes of high pitch sounding together produce a third whose vibrational number is the difference of the vibrational numbers of the two primary notes. If now we suppose a vibration at the rate of (say) 60,000 per second, another at the rate of 38,000 per second would give a difference note of 22,000 per second, which would be well within the range of audibility. If then we send up a note beyond the extreme limit of audibility, we shall be able to detect the presence of vibrations which exceed that of the note sent up by the highest number of vibrations of audible sound. It would be interesting to know if this has been attempted, and if the microphone can be applied to assist in the investigations.

Hirwain, Aberdare, January 10 D. M. LEWIS

Nepotism?

PLEASE, Mr. Editor, is a pet baboon (NATURE, vol. xxv. p. 217) more interesting than either a pet sparrow or a pet canary bird? Don't give rise to the suspicion that there is any nepotism in the affair! JOHN H. VAN LENNEP

Zeist, January 10

INDIAN FOSSILS.—Mr. J. W. Oliver informs us that at the Birmingham and Midland Institute there is a small collection of Siwalik fossils which, he understands, were sent some years ago from the British Museum. Prof. Prestwich writes that there is a very large and fine collection in the Oxford University Museum, presented by Dr. Falconer and Sir Proby Cantling. Prof. Prestwich will be happy to give Mr. Lydekker every facility for the examination of the specimens.

COMPRESSED AIR UPON TRAMWAYS

FEW persons unconnected with the practical working of the companies are aware of the great amount of time, labour, and money which have been devoted to the substitution of mechanical for horse-power upon tramways both in this country and abroad. The principal incentive to this exertion has been the large margin of saving which has presented itself in the light of a premium to inventors and capitalists. Motives of humanity towards the horses have also had considerable influence, especially with Parliament, and have contributed in no small degree to the legislative sanctions which have been obtained not only by particular companies, but by the tramway interest in general. In no case however that the writer is aware of, have the tramway companies themselves made any material contributions towards the solution of the problems involved. When the story of the subject comes to be written it will be found full of arguments in favour of the principle that the monopoly granted to inventors by the patent laws is nothing more than a clumsy method of spurring them to exertion, and of providing a remuneration for success which never covers the aggregate losses of failure by which the whole community have been indirectly benefited.

The fact of the horse-tramway companies having refused to assist inventors with money is fully accounted for and rendered excusable not only because they have no funds placed at their disposal by their articles of association for such a purpose, but also because the investment would have been far too speculative to have been sanctioned by the shareholders. Where the companies appear to the writer to have been at fault is that while the margin of saving as between a successful invention and horse-traction is admitted to be enormous, because the invention could hardly be said to be successful unless the margin was a large one, they have never admitted either individually or collectively that some substantial share of the saving should be the reward of the successful inventor. The writer has no hesitation in saying that if the leading companies had put the issue clearly before the inventive capacity of the engineering profession in the shape of an offer of say 30 per cent. of the actual saving in the shape of royalty to the inventor that the problem would have been solved at least six years ago. The far-stretching results of such a revolution, even within the comparatively confined area of the tramway interest, would be incalculable. Not to speak of the emancipation of the horses, the employment of capital in channels so consistent with the spirit of the age and the genius of the country as the manufacture of machinery would have economic results affecting the welfare of whole classes of the community, and the impetus given to the intramural locomotion of our large cities would go far to overcome the pressure of difficulties affecting the housing of the poor, which contribute more to the unrest of the people and the propagation of socialistic ideas than the wealthier classes are aware of. The policy of the tramway companies, however, appears to have assumed the character of a fixed determination to give nothing in return for the advantages which would accrue to them from the adoption of a successful mechanical substitute for horses. So long as they maintain this attitude the problem is likely to remain unsolved. Licensees of inventors have followed their example, and at least one case is known to the writer in which a gross breach of agreement has debarred the adoption of an invention which is notoriously efficient. Time no doubt will expose the guilty parties, and their names, instead of being honourably associated with the advance and improvement of mechanical science, will be handed down to posterity with the contempt which they deserve.

A description and illustration have already been given in these pages of a system of tramway traction by means of electricity, and this is no doubt safe in the hands of

the distinguished specialists who have taken it up. In the paper which the writer read recently before the Institute of Mechanical Engineers at Manchester, and which has already been reproduced in the engineering journals (see *Engineering*, vol. xxxii., No. 829), a sufficient explanation of his views was given upon the merits of the use of steam locomotives upon tramways compared with compressed air. The objections to steam were based principally upon its failure to comply with the necessary conditions of street traction in the matter of freedom from smell and dirt, and also on account of the excessive cost incurred by the maintenance of small high-pressure boilers and machinery. No such objections can be urged against the use of compressed air, as compared with electricity, because in both cases there is nothing to give trouble or annoyance from the residual products. In the one case the air escapes in its original purity to the atmosphere from whence it was derived, and in the other a still more subtle transference of force occurs, in which the conversion of one form of energy into another is all that takes place in order to effect the object aimed at. The overhead wire, in the Siemens system, which is the stage at which the invention at present stands, is a disadvantage as compared with a self-moving car in which no such obstruction is necessary to its working. Overlooking this objection to the rival system which may possibly be overcome by the use of accumulation of electric force in the vehicle itself, the point upon which the success of both must ultimately turn is that of their comparative economy. At present there are no figures to hand that can satisfactorily decide the question. In both cases a stationary engine is a necessary adjunct in order to supply a source of energy, and the future of both hinges (1) upon the comparative cost of the plant, and (2) upon the percentage of useful work which can be obtained from the use of compressed air and electricity respectively. These questions can only be answered by the trial of both upon a commercial scale, but it may safely be said in the meantime that there is nothing to lead to the conclusion that compressed air will appear to a disadvantage either as regards the necessary outlay in machinery or in the percentage of useful work to be obtained from it as compared with electricity.

The conditions which effect the useful effort exerted by a steam-engine through the intervening medium of a permanent elastic fluid such as air, employed as the ultimate vehicle of the original force upon a piece of mechanism, are first the loss from friction of the compressing apparatus; second, the loss represented by the difference between the temperature of the air as freshly compressed without radiation, and the temperature of the air as used in the second engine. These may be spoken of as the primary losses of energy. The secondary losses are: first, the friction of the secondary engine; and secondly, the losses arising from its inability to utilise the whole of the force contained in the air as compressed and cooled. Now the theoretical losses arising from these various causes are all easily determined, with the exception of that arising from the defects of the secondary engine, and this, which amounts to more than all the rest put together, not only varies in each separate case, but may be fairly looked upon as being capable of indefinite reduction by discoveries and improvements in the apparatus itself.

With regard to the fixed losses: the one which occurs from the loss of heat due to compression and subsequent cooling is one that can be restored under circumstances of peculiar economy, as there is perhaps no condition in the whole range of physics which lends itself so readily to the economical conversion of heat into work as raising the temperature of an elastic fluid under compression and making use of it at a corresponding pressure. It must be remembered, however, that what we are dealing with in practice is not so much the saving of every heat unit of the original supply for the purpose of producing a theoretical result and a beautiful experiment, as bringing the gross expense of the fuel used in the original steam-boiler to a point that leaves a sufficient margin as compared with horse traction, and in such a manner as not to interfere with the convenience of passengers. The writer has already in actual practice brought this gross sum per mile for fuel to $\frac{1}{2}$*d.* when coal is used costing 10*s.* a ton, a common enough price in districts where tramways are in use. Now in attempting to reduce the cost of fuel to a smaller fraction of a penny than $\frac{1}{2}$*d.* per mile run, it occurred to him that the effort should be made first in the direction in which the greatest loss occurred. This is certainly to be found in the defects of the secondary engine if an ordinary reciprocating steam-engine is employed, and an explanation of the writer's work in adapting it to the use of compressed air will be found in the paper already referred to. The result of his experience has gone to show that it is hopeless to obtain an economical result from reciprocating engines as at present arranged for the use of steam, without some special appliances such as he has adopted for making use of the ever-varying rates of expansion necessary in the case of a self-moving car. By reason of the additional apparatus required for re-heating the air resulting in grave inconvenience, and effecting an economy of perhaps not more than one-fifteenth of a penny per mile in fuel, he has not as yet included a heating appliance in the arrangements, and strong arguments would require to be brought to bear upon him before he determined upon doing so. The importance of introducing a heating apparatus would turn more upon what might by gained by adding to the capacity of a self-moving air-car with the view of making it capable of overtaking a particular journey for which the cold air was insufficient, than upon a mere question of economy, but even in this case he believes it would be more convenient and economical to add to the quantity and pressure of the air in the receivers than to make use of a separate heating appliance to obtain the same result.

Compressed air as a locomotive power is represented by three different systems, known respectively by the names of their inventors. All of them are more or less protected by patents, and taking the dates of the patent specifications as the standard of priority, the writer's stands first upon the list. The other two are known as Mékarski's and Beaumont's. The writer is the only one of the three who has made public in this country, otherwise than by patent specifications, the scientific work which he has overtaken, and the exact principles upon which his engines have been constructed. Before Col. Beaumont took out a patent at all he had driven in the writer's car and examined it, but as he has departed from his original specification the writer has had no means of comparing the efficiency of the engines, as recently constructed, with his own. On the occasion of his reading the paper at Manchester already referred to, a letter from Col. Beaumont was read by M. Bergeron, in which it was stated that the engine now running at Stratford used 10 cubic feet of air per mile at 1000 lbs. pressure per square inch, or 666 cubic feet at atmospheric pressure. This efficiency is more than 50 per cent. less than the writer's car, without allowing for the loss of power arising from the use of a heating apparatus, and the higher initial pressure of 66 as compared with 26 atmospheres to begin with. If this statement is correct the writer's views with regard to a moderate pressure and avoiding the use of a heating apparatus, except when absolutely necessary, are fully confirmed.

A heating apparatus, and reducing the initial pressure of the air by means of what is known as a reducing valve, are essential elements of the Mékarski system, but the engine would require to be considerably modified before it could comply with the requirements of the Board of Trade in this country.

The experiments which are now being made by the

Beaumont Compressed Air Engine Company at Stratford with a separate engine, hauling an ordinary passenger car behind it are likely to bring the question prominently before the notice of tramway companies, and the hopeful remarks made before the last meeting of the British Association by Sir Frederick Bramwell, with regard to the use of compressed air, must have contributed towards the same result. The experience of the writer, who has been longer at work on the subject than either of the representatives of the systems referred to is, however, so much opposed to their proposals, that he does not feel himself to be an altogether unbiased critic of their proceedings. It is sincerely to be hoped, for the sake of suffering horseflesh, and in order to promote the expansion of intramural locomotion throughout the country, that a fair trial may soon be given to the rival systems, including electricity. This, however, is but a remote contingency if tramway companies continue to adhere to the principle, or rather no principle, that they have to get everything, and the men who add to their dividends nothing, for their pains. The writer's car, which can be seen at work by any one interested, is entirely self-contained, and offers absolutely no obstructions to the convenience of passengers, and it carries forty of them a distance of more then seven miles with a low and safe pressure of air in the receivers, and without replenishing the supply. The distance it would travel with the pressure used in Col. Beaumont's engine is over twenty miles with one charge of air. The weight complete, including the fittings for passengers, is less than that of any compressed air tramway engine which the writer knows of, hauling a tramway car behind it.

W. D. Scott Moncrieff

SEA FROTH

I HAVE just read with interest Dr. Gladstone's article in NATURE (vol. xxv. p. 33) on "Sea Froth." I venture to inclose, as an illustration of his nephew's observations, portion of a description of such froth as witnessed by myself during a Mauritius hurricane, extracted from a book I am now publishing. It will be noticed how that close observer of nature, Bernardin de St. Pierre, depicted the same a century since in the same locality.

"This remnant of wreck had been washed bodily out of the deep water to within the outer barrier of reef on to a ledge, and was wholly out of the water, which position thus saved it from entire destruction, as only a portion of the enormous waves, which broke along the entire reef for miles, actually struck the remaining moiety, for the vessel had broken in two, and the stern-half had entirely been destroyed by the prodigious force of the breakers, the sound of which oceanic passion rose high above the din of the nearer dashing waves. Without the reef, sea and sky, ocean and air, were commingled, indistinguishable, 'a complete annihilation of the limit between sea and air.' Within the reef, the shallower sea presented a most wonderful sight, such as few can describe; it was what Bernardin de St. Pierre, nearly a century since, termed [1] '*Une vaste nappe d'écumes blanches creusés de vagues noires et profondes*'; and what Victor Hugo, in his 'Travailleurs de la Mer,' has aptly described in European waters as '*d'eau de savon,*' [2] a sea of soapsuds and lather, the lather flying in snowy flakes like thistle-down.

[1] The description given by Bernardin de St. Pierre of the view from the seashore on the north-east side of Mauritius is so true, and so evidently sketched from nature, that it will ever bear repetition. "Chaque lame qui venait se briser sur la côte s'avançait en mugissant jusqu'au fond des anses, et y jetait des galets à plus de cinquante pieds dans les terres; puis venant à se retirer, elle découvrait une grande partie du lit du rivage, dont elle roulait des cailloux avec un bruit rauque et affreux. La mer, soulevée par le vent grossissait à chaque instant, et tout le canal compris entre cette île et l'île Ambre n'était qu'une vaste nappe d'écumes blanches creusées de vagues noires et profondes. Ces écumes s'amassaient dans le fond des anses, à plus de six pieds de hauteur, et le vent qui en balayait la surface les portait pardessus l'escarpement du rivage à plus d'une demi-lieue dans les terres. A leurs flocons blancs et innombrables qui étaient chassés horizontalement jusqu'au pied des montagnes, on eût dit d'une neige qui sortait de la mer."—"Paul et Virginie" (Ed. 1879, Hachette).

[2] "La mer à perte de vue était blanche; dix lieues d'eau de savon emplissaient l'horizon."

"[Both the above authors, incomparable in their respective lines, have, it will be observed, used somewhat similar imagery, which is sufficient proof of its fidelity to realistic facts. I have only seen one painter's drawing which has at all even faintly attempted to copy these soapsuds of the sea, '*L'énorme écume échevelait toutes les roches,*' and that only on a small scale, viz. Mr. Frank Miles' study of a curling wave before it breaks on 'An Ocean Coast: Llangravieg, Cardiganshire' (No. 342), in Gallery No. IV. of last year's Academy.[1] The rendering of the blotches of foam,[2] which curdle on the hollow curved side and translucent crest of the breaking wave, are praiseworthy in their transcription, although their perspective has been blamed by some critics. '*L'écume ressemblait à la salive d'un léviathan.*' Mr. Miles ought to have given to his drawing the lines from Keats, quoted by Ruskin as the *perfect* expression of the peculiar action with which foam rolls down a long wave:

> "'Down whose green back the short-lived foam, all hoar,
> Bursts gradual with a wayward indolence.'

I cannot forbear giving Ruskin's imagery, as bearing out the above similes:—"The water from its prolonged agitation is beaten not into mere creaming foam, but into masses of accumulated yeast, which hang in ropes and wreaths from wave to wave, and where one curls over to break, form a festoon like a drapery from its edge; these are taken up by the wind, not in dissipating dust, but boldly in writhing, hanging, coiling masses, which make the air white and thick as with snow, only the flakes are a foot or two long each: the surges themselves are full of foam in their very bodies, underneath, making them white all through, as the water is under a great cataract; and their masses, being thus half water and half air, are torn to pieces by the wind whenever they rise, and carried away in roaring smoke, which chokes and strangles like actual water.' See 'Of Truth of Water' ('Modern Painters,' vol. i. part 2, sec. v. Chap. III. p. 375."

S. P. Oliver

ON THE HEIGHTS OF THE RIVERS NILE AND THAMES

COLONEL DONNELLY has put into my hands information from which the following results have been obtained:—

The information regarding the Nile has been derived from General Stone (Pacha), who has forwarded to the Science and Art Department a graphical representation exhibiting the height of the River Nile above the zero of the Cairo Nilometer for every five days, or six for each month from the beginning of 1849 to the end of 1878.

The information regarding the Thames has been derived from Sir F. W. E. Nicolson, who has forwarded a daily record of the levels on the lower sill of Teddington Lock when the tidal water has all drained off. This record extends from the beginning of 1860 to the end of 1880.

At present it is impossible to deduce from these records the volume of water which passes in unit of time across a section of these rivers: nevertheless the results give us a good deal of information, for we may be sure that an increase in depth denotes an increase in the volume of the water carried by the river and a decrease in depth a diminution of the same.

The results deduced I have embodied in a series of tables. In Table I. the yearly sum represents the whole area above the zero of the Cairo Nilometer of the graphical curve for the year in small squares whose base represents five days, and height one decimetre.

[1] An exhibition of paintings and drawings of "The Sea" is announced this winter, as to be held in the Gallery of the Fine Art Society, 148, New Bond Street.

[2] "Les flocons d'écume, volant de toutes partes, ressemblaient à de la laine."